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PRESS KIT

PROJECT: HELIOS-A

contents

NEWS
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D. C. 20546
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FOR RELEASE:
Immediate

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RELEASE NO: 74-314

HELIOS SET FOR DEC. 8 LAUNCH

A spool-shaped spacecraft named for the sun god of ancient Greece will be launched by NASA early next month toward the center of the solar system.

Helios-A, a solar probe built by West Germany as part of a joint venture with the United States, will lift off from Kennedy Space Center, Fla., aboard a Titan Centaur rocket about Dec. 8.

It will fly closer to the Sun than any previous spacecraft--within 45 million kilometers (28 million miles).

- more -

November 25, 1974

Encountering temperatures hot enough to melt lead, Helios will carry 10 experiments designed to obtain new information on interplanetary space in the region close to the Sun.

The instruments on Helios will measure the solar wind (ionized particles given off by the Sun), magnetic fields, solar and galactic cosmic rays, electromagnetic waves, micrometeoroids, and the zodiacal light.

Additionally, information concerning celstial mechanics, relativity and the Sun's atmosphere will be derived from analysis of spacecraft radio signals and tracking data.

Instrumentation related to that carried on Helios is also carried on two Interplanetary Explorers or IMPs (Explorers 47 and 50) in Earth orbit; the Pioneer spacecraft orbiting the Sun at about one Astronomical Unit,* and on Pioneers 10 and 11 in the outer solar system.

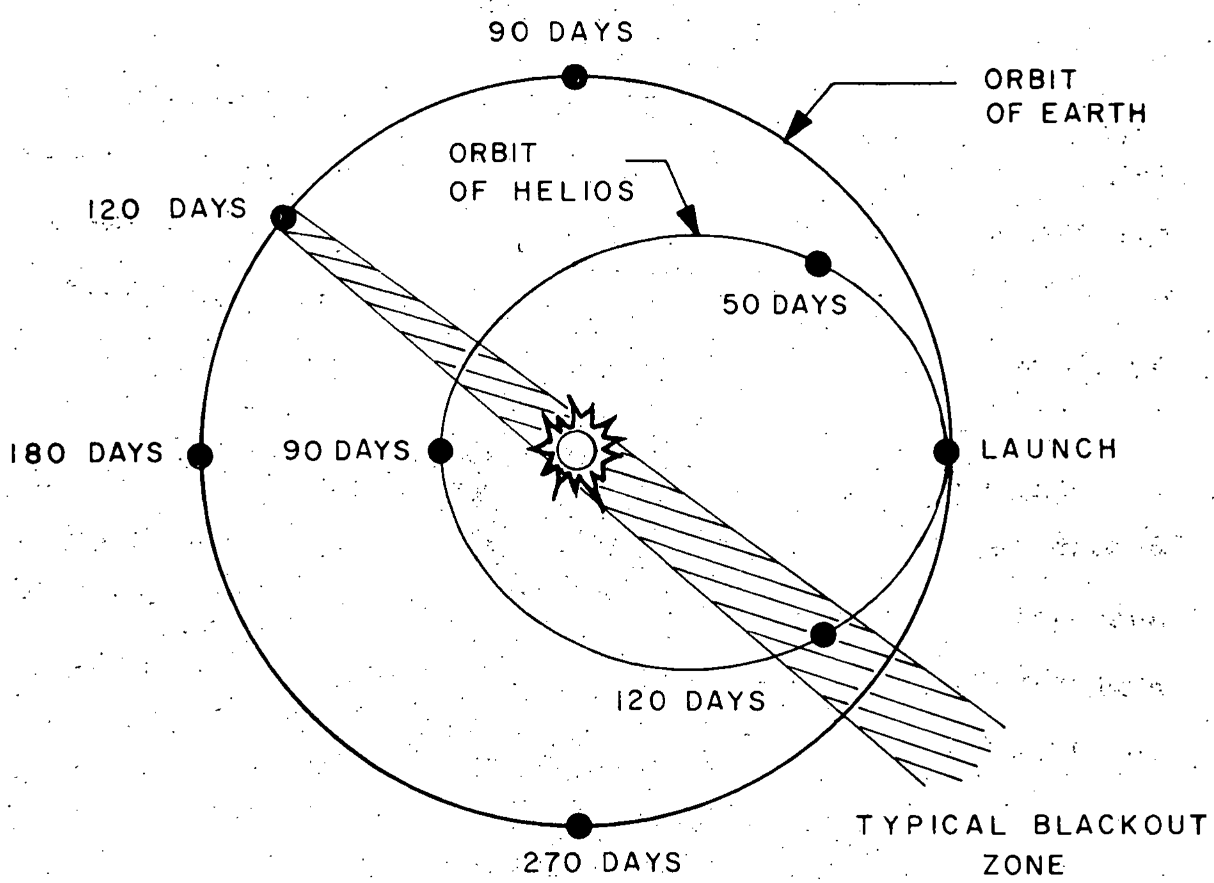
*An astronomical unit (A.U.) is the average distance between Earth and Sun, 149.7 million km or 93 million miles.

Because these spacecraft measure solar phenomena from various points in the solar system over a long period of time and under varying conditions, the correlation of their data with that received by Helios will be a major part of the Helios scientific effort.

With the launch of a second Helios, a year to 18 months later, information from the two spacecraft will be received simultaneously from widely differing locations for comparison with each other and with data taken from the Pioneers and IMPs.

The two Helios spacecraft are designed for at least an 18-month lifetime, although the missions will be considered successful after the first perihelion pass is completed, approximately 100 days after launch. The second Helios may approach a bit closer to the Sun than the first, to about 0.28 A.U. or 41,660,000 km (26 million miles).

Three of the 10 experiments aboard the high sophisticated German spacecraft are American. The U.S. also supplies the launch vehicle, tracking and data acquisition, and technical support.



HELIOS and Earth Orbits

Germany's Bundesministerium fur Forschung und Technologie (BMFT) (Ministry for Research and Technology) has overall management responsibility, and the Deutsche Forschungs-und Versuchsanstalt fur Luft und Raumfahrt (DFVLR) (German Aerospace Research and Experimental Establishment) serves as project manager.

NASA's Goddard Space Flight Center, Greenbelt, Md., is responsible for U.S. participation, and Lewis Research Center, Cleveland, Ohio, provides the Titan Centaur rocket.

The solar magnetic field is being drawn out by solar plasma in ever widening spirals away from the Sun, at least beyond Jupiter and possibly beyond Saturn, 5 and 9.5 AU from the Sun respectively. This magnetic field and plasma eventually establishes a boundary between our solar system and the rest of the Galaxy. Energetic particles from the Galaxy or other parts of the universe impact against this boundary, but only the relatively high energy particles actually go through it.

GSFC Helios Project Scientist Dr. James H. Trainor, who is also a Pioneer 10/11 experimenter, comments:

"Helios will not only take our instruments in closer to the Sun than man has ever been able to go, it will provide scientific observations of activity on the back side of the Sun as seen from Earth. This hiddel activity may well be responsible for interplanetary effects seen near Earth.

"Additionally Helios will be occulted by the Sun at fairly close distances to the Sun, allowing fine measurements in the fields of relativity, celestial mechanics and density measurements in the high altitude solar atmosphere."

With Helios behind the Sun or directly in front of it, there will be so much solar noise at times that the spacecraft will not be able to communicate with Earth. However, information on far-side solar activity ordinarily can be transmitted to Earth almost as it happens, with data obtained during the blackout periods stored for later transmission.

Complex problems of system management and thermal control presented significant challenges to the German research team. Helios-A passed its most important test last Spring when it withstood six days of the highest temperatures ever demanded of a spacecraft at NASA's Jet Propulsion Laboratory, (JPL), Pasadena, Calif. During the tests in a 7.5-meter (25-foot) simulator, the despun reflector temperatures were raised to 370 degrees Centigrade (700 degrees Fahrenheit) for about 10 days. That's the highest temperature espected at 0.3 AU. The simulated solar radiation survived was 11 times the solar intensity at the outer edge of the Earth's atmosphere.

To protect the spacecraft from overheating, the German team designed Helios so that all payload components in the central body compartment would dissipate heat as independently as possible. The heat from the central compartment is radiated to space mainly in an axial direction from the radiating areas on the top and bottom via louver systems. Also there are optical surface reflectors or second surface mirrors on the outside of the compartment and several layers of insulation between the reflectors and payload. In addition, the spacecraft spins once every second to evenly distribute the heat coming from the Sun.

Experiment area temperatures will be kept between -10 degrees C. (14 degrees F.) and +30 degrees C, (86 degrees F).

However, unique thin wires of 0.2 millimeters (.009 inches) diameter on the high-gain antenna reflector will withstand temperatures of 500 degrees C. (932° F.), while a bearing system developed for the reflector will use a dry lubricant suitable for the full range of temperatures Helios will encounter.

The experiment compartment or central body is 1.75 meters (5.7 feet) in diameter with a height of 0.55 meters (1.8 feet). It is a 16-sided cylinder, with two conical solar arrays attached to both ends giving it a spool shape. The largest diameter of the solar arrays is 2.77 meters (9.1 feet) and the height of the probe without the antenna mast is 2.12 meters (7.0 feet). With the antenna mast, it is 4.20 meters (13.7 feet) tall. Two deployable booms attached to the central body measure 32 meters (105.0 feet) tip-to-tip. They will be used as antennas for a radiowave experiment.

Communication between Helios and Earth is possible during the entire mission, except when the spacecraft passes behind or in front of the Sun. Depending on the phase of the mission, the spacecraft will be controlled from NASA's Deep Space Network (DSN), managed by JPL, or the German Space Operation Center (GSOC), near Munich.

During the first phase, beginning at launch and lasting about three weeks, a German mission operations team located at JPL will control the spacecraft. After that, the mission control team will be relocated to GSOC, with DSN continuing to provide tracking and data acquisition support.

The mission will be the first operational flight of the Titan Centaur rocket, assembled primarily for the coming Viking expedition to Mars.

The new vehicle combines NASA's versatile Centaur upper stage with the Titan III booster developed by the United States Air Force. Centaur, the nation's first high-energy liquid hydrogen-liquid oxygen rocket, develops 133,440 newtons (30,000 pounds) of thrust at altitude.

The Titan consists of a two-stage liquid propellant core rocket, and has two large 120-inch diameter strap-on solid rocket motors which develop 10.6 million newtons (2.4 million pounds) thrust at liftoff.

The maiden flight of the Titan Centaur took place last February. After a flawless liftoff, the Centaur's main engines failed to ignite and it had to be destroyed by the range safety officer. Nevertheless, sufficient data were received from the flight to show that successful integration of the two vehicles had been accomplished.

Cost of the two Helios missions, including spacecraft and launch vehicle, is about $260 million. The German share is about $180 million. The German Ministry for Research and Technology pays spacecraft costs, which include the price of two flight units, a prototype, and thermal, structural and engineering models. Germany provides seven experiments, plus command and data acquisition costs for the German ground stations.

The U.S. pays for the two launch vehicles and their support, tracking and data acquisition services, the three U.S. experiments, and other support for a total of about $80 million.

Prime contractor for the spacecraft is Messerschmitt-Bolkow-Blohm GmbH, Munich. The Titan III booster is built by the Martin Marietta Corp., Denver, Colo., under contract to the Air Force Space and Missiles System Organization (SAMSO) acting as the procurement agency for Lewis Research Center. The Centaur upper stage is produced by General Dynamics/Convair.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

HELIOS FACT SHEET

SPACECRAFT

Weight: 370 kilograms (815 pounds) including 10 scientific experiments weighing a total of 72 kilograms (158 pounds).

Structure: Spool-shaped with an experiment compartment or central 1.75 meters (5.7 feet) in diameter, cylindrical in shape (16 sides) and two conical solar arrays attached to both ends giving it spool shape.

Height with antenna mast, 4.20 meters (13.7 feet). Without antenna mast, 2.12 meters (7.0 feet). Diameter at widest point (solar arrays) 2.77 meters (9.1 feet). With deployable booms extended, 32 meters (105.0 feet) tip to tip.

Power: Solar cells located on solar arrays mounted above and below the spacecraft central body. Second surface mirrors are interspersed among solar cells to radiate excess heat. Cells supply minimum of 240 watts at aphelion (farthest from Sun) and considerably more at perihelion. Silver-zinc batteries provide power during initial phase of mission.

Telemetry and Command:

The telemetry subsystem processes the scientific and engineering data for transmission. It is the connecting link between the various data sources and the communications subsystem. Data from the ten scientific experiments and spacecraft housekeeping are merged and formatted in the data encoder for direct transmission to Earth. The data handling equipment consists of a command decoder, data storage with a 500 kilobit core memory, an encoder and a telemetry control unit. The spacecraft is controlled by ground command.

Tracking and Data Acquisition:

The DSN unified S-band system will be used for telecommunications utilizing the 26 meter (85 feet) antenna and the 64 meter (210 feet) antennas when available in the early phases. About launch plus three weeks, mission control will be transferred to the German Space Operation Center (GSOC), Munich. German Control Center (GCC) will interface with NASA's NASCOM facility in Madrid. The 100-meter (325 foot) antenna at Effelsburg Germany, will be used as required, but only for telemetry reception.

Orbit:

Elliptical, from one AU to 0.3 AU. 180-day period.

- more -

BACKGROUND

During a 1966 meeting in Washington, D.C., between President Lyndon B. Johnson and Chancellor Ludwig Erhard, it was agreed that the Federal Republic of Germany and the United States would undertake a major cooperative space project. Such a project would serve to carry out NASA's legislative mandate to pursue foreign cooperation, while at the same time substantially increasing the space technology capability of Germany. As a direct result of that meeting and numerous bilateral discussions, the Germany Ministry for Scientific Research and NASA agreed in June 1969 to cooperate in a project for the exploration of interplanetary space to be known as Project HELIOS. Under this agreement, as outlined in a Memorandum of Understanding, Germany would develop flight spacecraft with both American and German scientific instruments aboard. The spacecraft would be launched by the United States on two separate missions toward the Sun, with the general scientific objective of providing new understanding of fundamental solar processes and solar terrestrial relationships. Additionally, the United States agreed to provide technical consultation as appropriate, training as required, and tracking and data acquisition support as mutually agreeable.

HISTORY OF HELIOS COOPERATIVE PROJECT

UNITED STATES/GERMANY

- Beginning--September 1966 (Johnson/Erhard)
- Discussions--1967, 1968 (Webb/Stoltenberg)
- Mission Definition--July 1968 to April 1969
- Memorandum of Understanding--June, 1969 (Paine/Stoltenberg)
- Presidential Statement--August 1969 (Nixon/Kiesinger)
- First working Group Meeting--September 1969 (Bonn)
- Launch Schedule--12/74 and 12/75

PRINCIPAL CONTRIBUTIONS

- Germany--Spacecraft (including experiment integration)
  seven experiments
  100 meter (325-foot) antenna

- United States--Titan/Centaur/TE-364-4 (Two)
  Three Experiments
  DSN 26-and 64-meter (85-and 210-foot) Antennas
  Launching
  Technical Advice

MISSION OBJECTIVES

The main scientific objectives of the Helios mission are the exploration of interplanetary space.

* To study the spatial gradient of the interplanetary medium by measuring the magnetic field, the density, temperatures, velocity and direction of the solar wind i.e. electrons, protons and alpha particles.

* To study discontinuities and shocks in the interplanetary medium magnetically, electrically and by observing the behaviour of the solar wind particles.

* To study radio waves and in situ the electron plasma oscillations believed responsible for Type III radio bursts and other wave-particle interactions.

* To study the propagation of solar cosmic rays and to a certain degree their spectral composition.

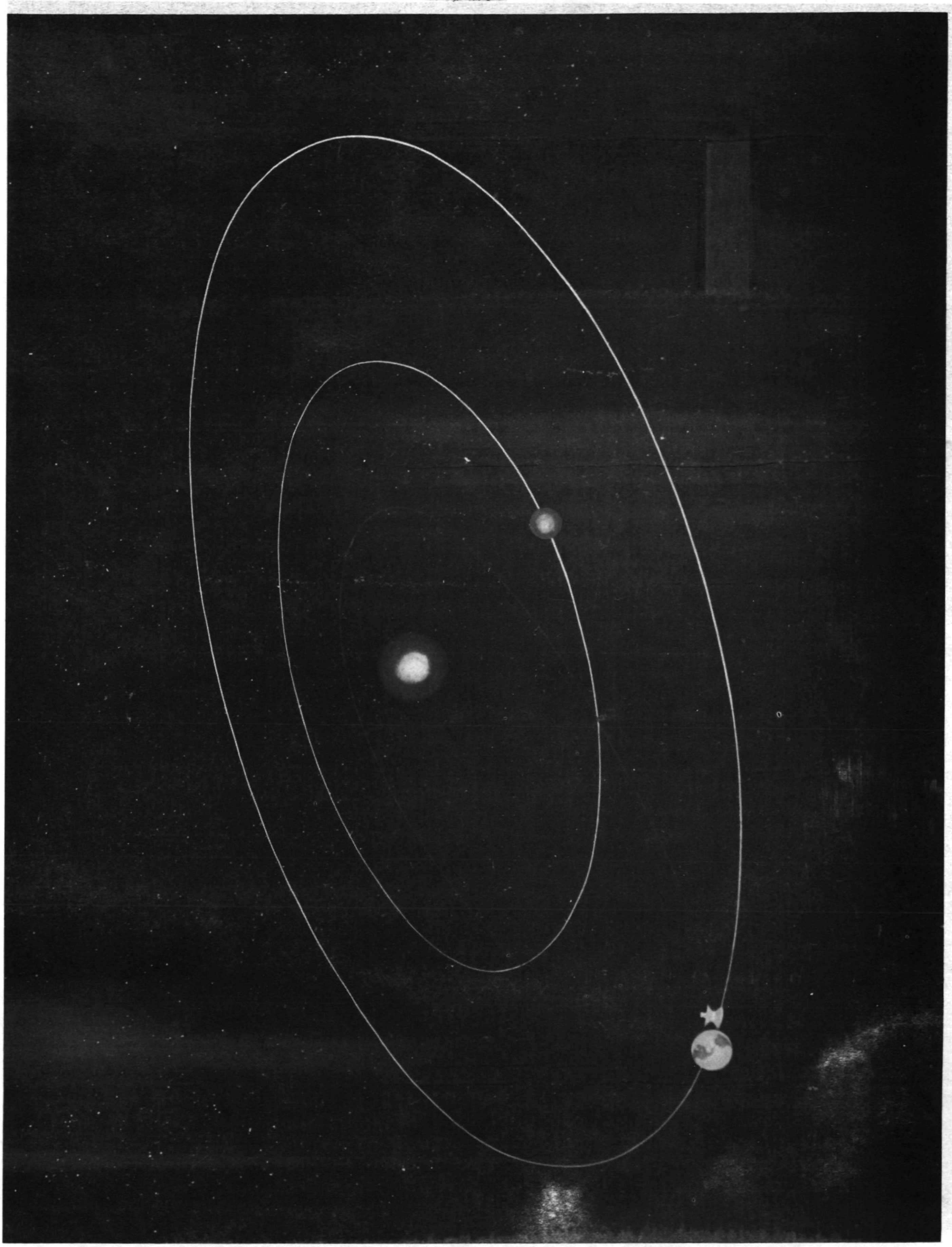
* To measure the spatial gradient of galactic cosmic rays, to separate the solar and galactic components of the low energy cosmic ray flus especially with respect to protons and electrons.

* To study the spatial gradient and dynamics of the interplanetary dust and the cehmical composition of dust grains by observing the zodiacal light and by counting and analyzing individual dust particles.

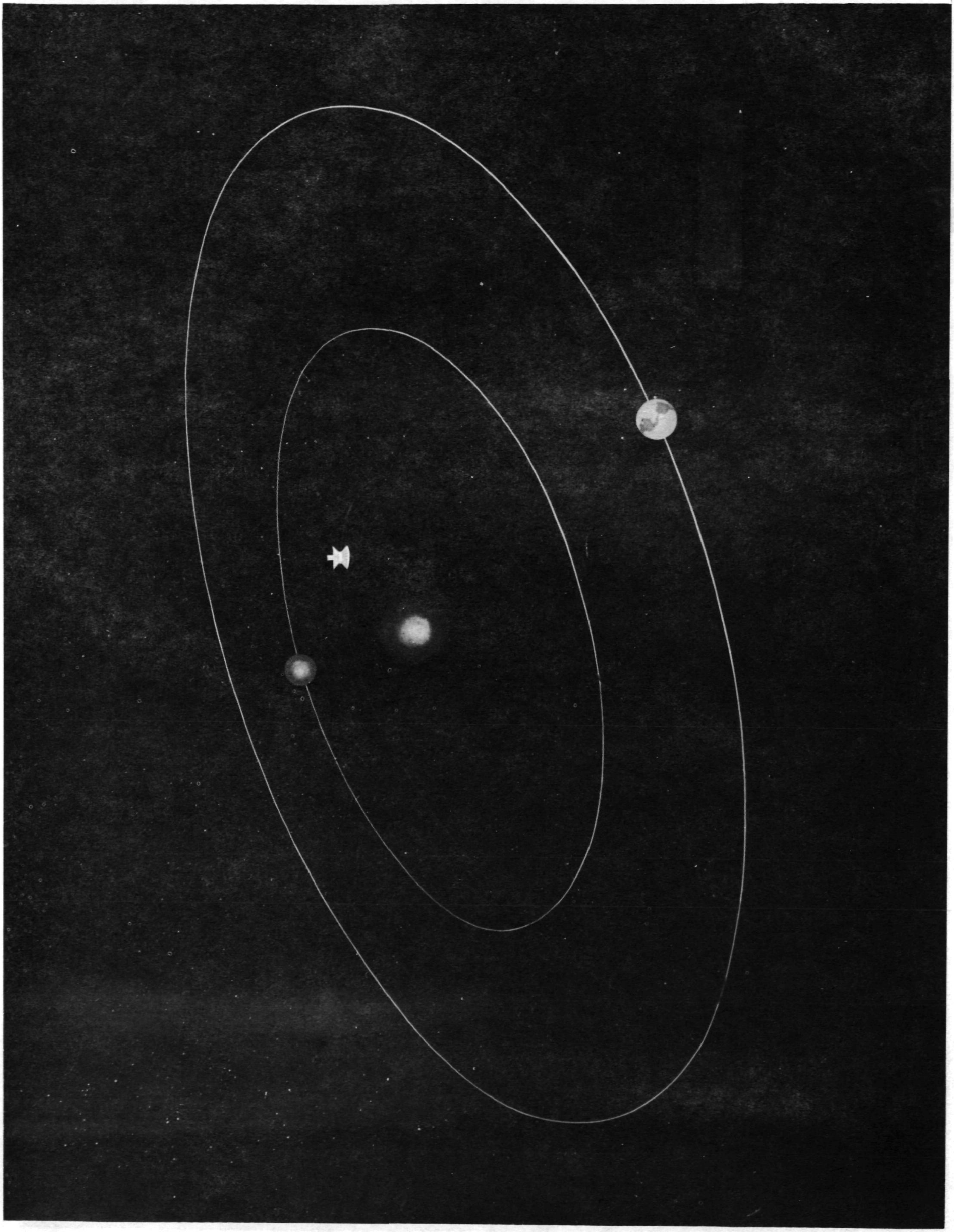
* To x-ray monitor the solar disk by means of a Geiger-Muller counter. This device will enable the experiments to monitor the back side of the Sun from orbit regions far from the Earth.

* To test the theory of general relativity with respect to both orbital and signal propagation effects

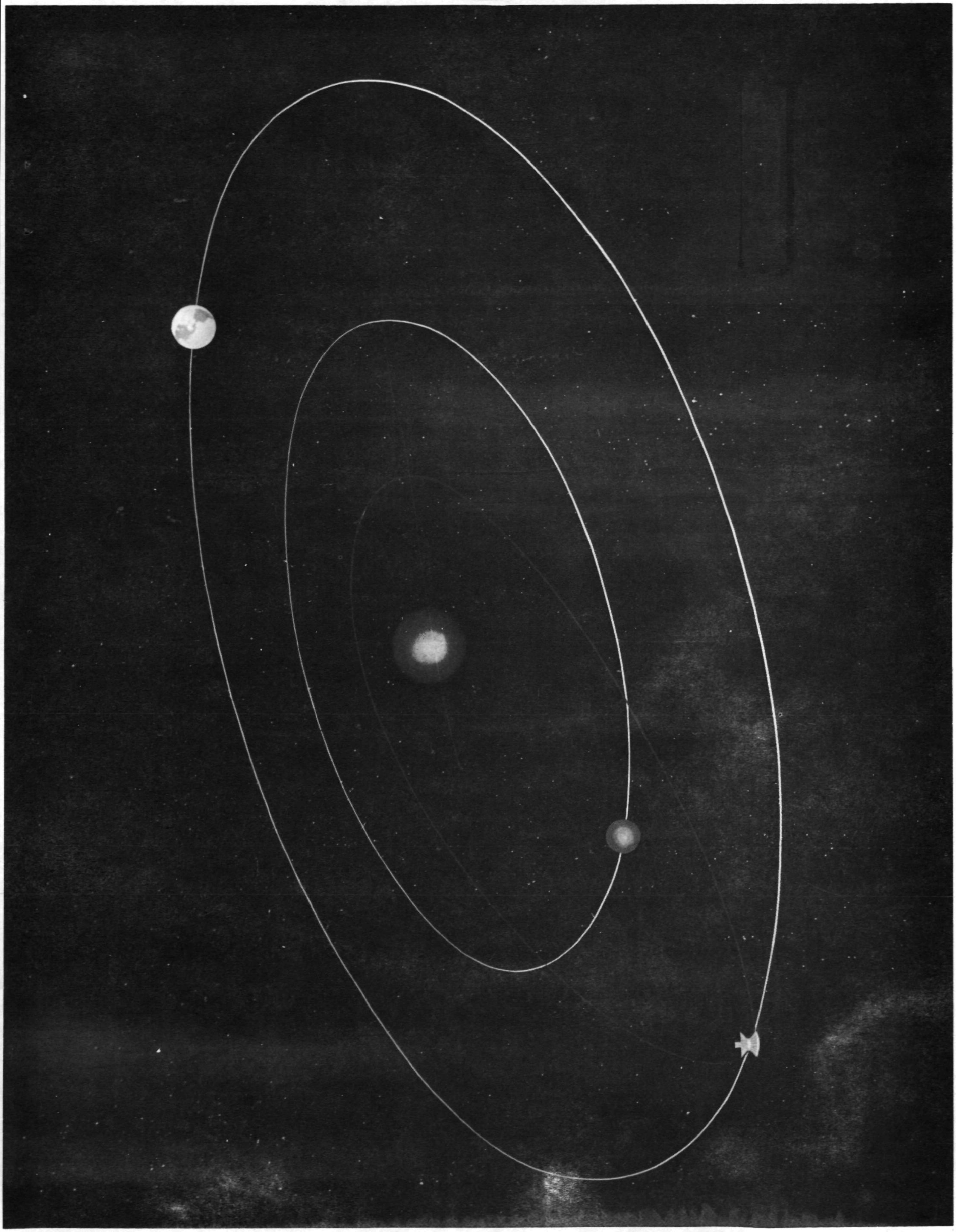
  —Determination of the dynamical oblateness of the Sun
  —Determination of the quadrupole mass distribution of the Sun
  —Improvement of the ephemerides of the inner planets and the Moon



LAUNCH



LAUNCH + 95 DAYS



LAUNCH + 190 DAYS

THE SPACECRAFT

The 370-kgm (815-lb.) spacecraft has a short 16-sided cylindrical central body with two conical solar arrays attached at both ends of the central body. The central body is formed by circular equipment platforms at each end and eight radial equipment platforms which join the upper and lower platform. The spacecraft equipment and the experiments are mostly mounted on the radial platforms within the central body.

The central body is attached at its lower end to a circular adapter which mates with the launch vehicle.

Above the central body, within and protruding above the upper solar array, is the telecommunications antenna system. It consists of a narrow beam high-gain antenna (23 db) with a mechanically despun reflector. Above the high-gain antenna sits a medium-gain antenna (toroidal pattern, 7 db) and on top of the antenna mast is a third antenna system with a quasi-isotropric pattern.

The spacecraft has two deployable double-hinged booms which carry the three magnetometer experiments. These two rigid booms are diametrically opposite to the central body. Two deployable booms also diametrically opposite to one another and perpendicular to the rigid boom are attached to the central body. They are used as antennas for a radiowave experiment and measure in deployed configuration 32 meters (105 feet) tip to tip.

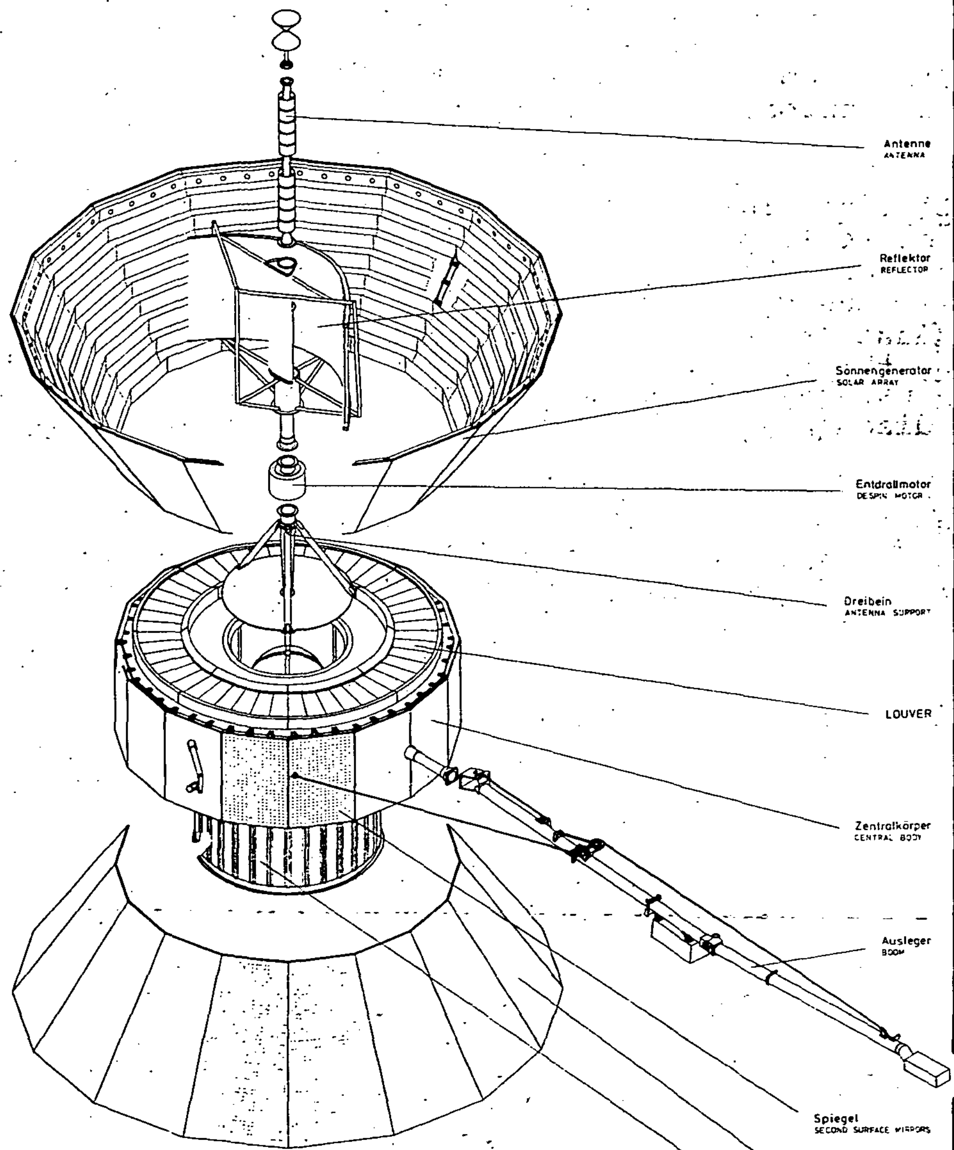
Most of the spacecraft equipment and the experiments are mounted on the radial platforms within the central compartment. The exceptions to this mounting concept are the rigid magnetometer booms, the flexible experiment antennae and several long telescopes which view out of the lower surface of the central body, they are mounted partially within the adapter section.

The diameter of the central compartment is 1.75 meters (5.7 feet) its height 0.55 meters (1.8 feet). The largest diameter of the solar arrays measures 2.77 meters (9.1 feet), the height of the probe without antenna mast 2.12 meters (7.0 feet) and with antenna mast 4.20 meters (13.7 feet).

POWER SUBSYSTEM

The components comprising the power subsystem are solar panels, batteries, and regulators.

HELIOS



Gesamtansicht mit Ausleger, ausgeklappt

GENERAL VIEW WITH BOOM UNFOLDED

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Solar Panels-- The solar cells are mounted on two truncated cones which are in turn mounted above and below the spacecraft equipment compartment (center section). Second-surface mirrors are interspersed among the solar cells. These devices radiate excess heat and provide an efficient means of colling the array. Individual solar cell temperatures are constained to a maximum of 165° C. at perihelion. The power output of the solar cell array is a minimum of 240 watts at aphelion and increases significantly as the spacecraft approaches perihelion.

Batteries--The batteries supply load-power from five minutes prior to launch until the solar array assumes the load. In addition, the 8.0-Ah battery must be capable of delivering pulse energy for pyrotechnic devices (boom deployment, etc.). Because it provides a high energy density of 20-30 watt-hours/ lb., the silver-zinc battery has been chosen for the mission. The battery voltage is monitored from the ground and it may be disconnected or reconnected to the main bus by command.

Regulator--The regulated bus technique will be used in the power subsystem. This yields high overall spacecraft system reliability through circuit simplicity, low component power dissipation, and predictable electrical interface characteristics.

Regulation is provided at 28 volts +2 per cent. The solar array output is filtered in order to maintain the low ripple requirements imposed by the experiments.

THERMAL CONTROL SUBSYSTEM

The thermal control is both active and passive. The main equipment compartment is protected from variations of the external thermal environment by multiple layer insulation blankets. Heat is removed from the temperature-controlled central compartment by individually actuated, temperature-controlled louvers. To prevent the louvers from heated reverse surfaces of the solar array, a shield system surrounds the louvers.

Heat is radiated from the Helios central compartment to space mainly in an axial direction from the areas on the top and bottom plates of the central body. The control is active by louver systems.

Most equipment in the central compartment will remain in the temperature range from -10°C. (14°F.) to +30°C. (86°F.) for the entire mission.

The temperature of the solar array is controlled by using 50% second surface mirrors interspersed among the solar cells. Excess heat from the solar cells is re-radiated to space by the second surface mirrors. The solar cell temperatures will be maintained below 165°C. (330°F.) during the entire mission.

Heaters are also used as active thermal control elements when other passive means are inadequate to maintain a sufficiently higher temperature for certain components.

ATTITUDE CONTROL SUBSYSTEM

The HELIOS attitude control subsystem adjusts and actively maintains the spin rate (nominally 60 rpm) and attitude of the spacecraft, controls the despin and pointing of the high-gain antenna, and provides sun reference pulses to the esperiments. The attitutde control subsystem maintains requisite spacecraft attitude in orbit by use of sensing systems that reference to the Sun and stars, a propulsion system, and damper. A direct current stepper motor despins the antenna.

The d.c. motor drives the high-gain antenna reflector in a direction opposite the spin of the spacecraft so that it remains stationary with respect to the spacecraft-sun line. The angle can be changed by command to point toward the Earth.

TELECOMMUNICATIONS

The HELIOS spacecrfft telecommunications subsystem is designed for support by the 26-meter (85-foot) antenna in the DSN, and is flexible enough to take advantage of the enhanced data rates possible when utilizing the 100-meter (325-foot) German Effelsberg antenna and when the 64-meter (210-foot) DSN antenna are available.

COMMUNICATIONS AND TELEMETRY

The communications system (RF subsystem) provides for the transmission of scientific and technical data to the ground as well as receiving commands from the ground and transferring the commands to the spacecraft subsystems and experiments.

Three antennas are used: high gain, medium gain, and low gain. The high-gain antenna utilizes a mechanically despun parabolic reflector. In the event of failure of the despin mechanism the medium gain antenna will be used. Transmission to Earth can be accomplished on any of the three antennas at three selectable power levels. The combination of the high gain antenna and the high power amplifier will result in a maximum down-link data rate of 4096 bits per second.

In normal operation, data from the onboard experiments and spacecraft data (housekeeping) is merged and formatted in the data encoder for direct transmission to Earth. During times when there is no communication with the Earth, the data is routed to core storage for delayed transmission to Earth. Core storage is also employed to record high resolution data from the magnetometers and plasma experiments during periods of magnetoplasmadynamic shock.

RANGING AND DOPPLER

Coherent transponder operation is selectable by telecommand. In this case, the transmitted down-link frequency is coherently derived from the received up-link frequency and allows very accurate two way doppler measurements which, together with the measured direction of arriving signals, are used for orbit determination and predictions for tracking.

For celestial mechanics experiments, a pseudo-random range code can be sent from the Deep Space Network. The ranging video code is detected on the spacecraft and remodulated on the down-link carrier. This allows extremely accurate range measurements to be made accordint to an overall ranging signal uncertainty of less than 100 nanoseconds (one tenth of one millionth of a second).

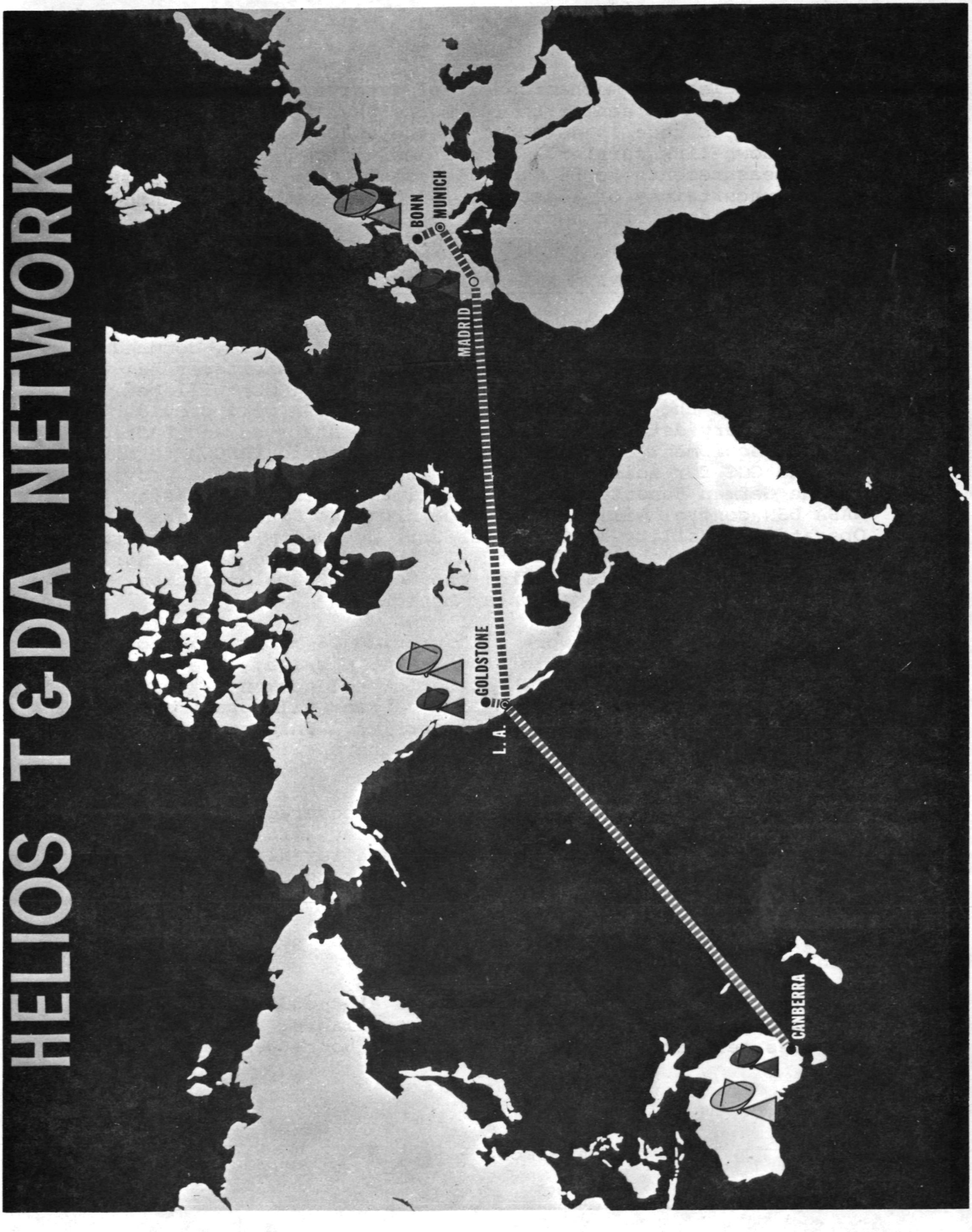
TRACKING AND DATA ACQUISITION

The HELIOS Project will be supported by the Deep Space Network (DSN) and the German communications system, command station, and data center. The various data interfaces between the DSN and the German Control Center (GCC) will be connected at the Madrid NASCOM station. NASA will provide the necessary data links between all its stations and Madrid, and the equipment and lines between the Madrid NASCOM terminal and the GCC for telemetry and high speed data will be provided by the German Bundespost. At all times during the mission, NASA DSN control will be exercised from the Space Flight Operations Facility (SFOF), Pasadena. Overall mission control is a German responsibility and will be exercised in the early phases from JPL and later from the German Space Operation Center in Oberpfaffenhofen near Munich.

The Deep Space Network will provide 26-meter (85-foot) antenna coverage for most of the HELIOS mission. The DSN unified S-band system will be used for telecommunication. A single coherent up and down link carrier will provide two-way doppler and a data reference carrier. This carrier is modulated with ranging <u>or</u> command on the up-link and ranging <u>and</u> telemetry on the down-link.

The DSN will provide three-station coverage with its 26-meter antenna network, 24 hours per day, from launch to forst solar occultation. DSN coverage after first occultation will be on a shared basis with other competing space projects. In addition, DSN coverage by the 64-meter (210-foot) network will be provided on a competing basis with other programs, but on a priority basis during first perihelion (minimum of one pass per day).

The 100-meter (325-foot) antenna at the German Efelsberg station, near Bonn, will be used as available. This station provides telemetry reception only, four hours per day, year-round.


HELIOS T&DA NETWORK
BONN
MUNICH
MADRID
GOLDSTONE
L.A.
CANBERRA

Telemetry data and orbit data as well as telecommands recorded on magnetic tapes at the telemetry ground stations and/or at the control centers will be mailed to the German Data Center (GDC) and to GSFC for processing.

Data will be obtained at remote DSN stations and forwarded to the Jet Propulsion Laboratory (JPL), in real time (within one second). This data will be processed within light days and provided to the Goddard center and the German Control Center on duplicate master data records (MDR). These are used to prepare individual experiment data records (EDR) for distribution to each experimenter within 30 days. The German control center processes and distributes scientific data received at the Effelsberg station in a similar manner. Engineering data obtained at the ground stations is handled the same way. Engineering data is also sent to the German Control Center in realtime over high speed data lines to provide the required information for spacecraft control.

HELIOS SCIENTIFIC EXPERIMENTS

No.	Title	Investigators (Princ. Invest., underlined)	Affiliation	Scientific Objectives: Measurement of
1	Plasma Experiment	H. Rosenbauer R. Schwann J. Wolfe	MPI f. Physik u. Astrophysik, Institut f. Extraterr. Physik, Garching/München NASA Ames Research Center, Moffett Field, Calif.	low energy charged particles (solar wind)
2	Flux Gate Magnetometer (Braunschweig)	G. Musmann F.M. Neubauer A. Maier	TU Braunschweig, Institut f. Geophysik u. Meteorologie	interplanetary quasistatic magnetic field (0 to 4.7 Hz) and shock waves
3	Flux Gate Magnetometer (Roma, GSFC)	N.F. Ness L.F. Burlaga F. Mariani S. Cantarano	NASA-GSFC, Greenbelt, Md. Universita degli Studi, Istituto di Fisica "G. Marconi", Roma	interplanetary magnetic field
4	Search Coil Magnetometer	G. Dehmel F.M. Neubauer	TU Braunschweig, Institut f. Nachrichtentechnik TU Braunschweig, Institut f.Geophysik u. Meteorologie	field fluctuations and shock wave forms (5Hz to 3KHz)
5	Plasma and Radio Wave Experiment	D.A. Gurnett P.J. Kellogg S.J. Bauer R.G. Stone R.R. Weber	University of Iowa, Dep. of Physics a. Astronomy, Iowa City, Iowa University of Minnesota, School of Physics a. Astron., Minneapolis, Minnesota NASA-GSFC, Greenbelt, Md.	Radio wave measurements from 50 Hz to 2 MHz Plasma measurements 10 Hz to 100 KHz
6	Cosmic Ray Experiment (Kiel)	H. Kunow R. Müller G. Green	Universität Kiel, Institut für Reine u. Angewandte Kernphysik	protons, alpha particles, and heavier nuclei of solar and galactic origin
7	Cosmic Ray Experiment (GSFC)	J.H. Trainor F.B. McDonald B.J. Teegarden E.C. Roelof K.G. McCracken	NASA GSFC, Greenbelt, Md. University of New Hampshire CSIRO, Melbourne, Australia	medium and high energy particles and X-rays
8	Electron Detector	E. Keppler B. Wilken G. Umlauft D. Williams	MPI f. Aeronomie, Institut f. Stratosphärenphysik, Lindau/Harz ESSA, Boulder, Col.	medium energy electrons, protons, and positrons
9	Zodiacal Light Photometer	C. Leinert E. Pitz H. Link	Landessternwarte Heidelberg	zodiacal light wave length and energy measurements of interplanetary dust particles
10	Micrometeorid Analyzer	H. Fechtig E. Grun J. Kissel P. Gammelin	MPI für Kernphysik, Heidelberg	dust particles man and energy measurements of interplanetary dust particles
11	Celestical Mechanics Experiment	W. Kundt W.B. Melbourne J.D. Anderson	Universität Hamburg, I. Institut f. Theoretische Physik JPL, Pasadena, Calif.	orbit parameters in order to test general relativity theories
12	Faraday Rotation Experiment			

LAUNCH VEHICLE

The Helios mission is the first operational mission for the Titan Centaur vehicle. The only other flight of a Titan Centaur took place on February 11, 1974, to test the launch vehicle's readiness to undertake a wide variety of missions including the Viking mission to Mars. During the flight the Centaur main engines failed to ignite and the Centaur had to be destroyed by the range safety officer. However, sufficient data was received from the flight to show that integration of the two vehicles has been successfully accomplished.

A special board established by NASA to review the Titan Centaur Proof Flight concluded that failure of the liquid oxygen boost pump prevented the Centaur main engines from starting. Three possible causes of the boost pump failure were identified and 11 recommendations made to prevent failure from reoccurring. The recommendations included procedural changes during manufacture, testing and launch preparation and certain hardware changes to support these new procedures. All of the recommendations have been implemented.

The Titan Centaur will proceed through a normal operational mission consisting of the Titan boost phase and two burns of the Centaur stage. Following the second Centaur burn, a fourth stage with the Helios spacecraft will be separated and will inject the Helios spacecraft into a heliocentric (sun centered) orbit. This will be the first flight of the spin-stabilized fourth stage on a Titan Centaur launch vehicle.

Following the successful insertion of Helios into solar orbit, the Centaur will begin an extended mission and will carry out several experiments designed to test its ability to directly insert spacecraft into Earth synchronous orbits. Such missions require long coast periods, up to 5 hours, and restart of the main engines with relatively small amounts of propellants remaining in the tanks.

The Titan Centaur launch vehicle combines a Titan IIIE booster and Centaur D-1T third stage. It has an overall height of 48.8 meters (160 feet) and a total liftoff weight of 64,000 kilograms (1.4 million pounds). For the Helios mission a fourth stage, the Delta solid rocket motor kick stage will be employed.

A new type of shroud, called the Centaur Standard Shroud (CSS) covers the entire third stage vehicle and its payload. It measures 17.6 meters (58 feet) long and is 4.2 meters (14 feet) in diameter, and will accommodate a spacecraft nearly 8.5 meters (28 feet) in length.

TITAN IIIE

The Titan IIIE booster consists of a two stage liquid propellant core vehicle and two strap-on solid rocket motors, each 3 meters (10 feet) in diameter and 25.9 meters (85 feet) long. The two solids, which are made up of five segments each, provide a thrust of 10.6 million newtons (2.4 million pounds) at liftoff.

The 3 meter (10 foot) diameter core stages are primarily constructed of aluminum alloys. They are made with aluminum skins with T-shaped aluminum stringers integrally milled. The length of the first stage is 22.2 meters (72.9 feet) and the second stage 7.1 meters (23.3 feet).

A heat shield assembly protects the Stage I engine from the high temperatures generated by the solid rocket motors. The heat shield encloses a major portion of the engine from the thrust chamber throats upward.

The two core stages burn a 50-50 blend of hydrazine and unsymmetrical dimethylhydrazine (UDMH) fuel and nitrogen tetroxide oxidizer. The first stage uses an Aeroject YLR87-AJ-11 engine with two gimballing thrust chambers. It can burn for approximately 148 seconds and provides 2,340,000 newtons (520,000 pounds) thrust. The second stage Aeroject YLR91AJ-11 engine has a single thrust chamber and provides 446,000 newtons (101,000 pounds) thrust for about 208 seconds. Both the first and second stage engines are regeneratively cooled and turbopump fed.

Control for Stage I is achieved by gimballing the engines. The gimballed main engine provides pitch and yaw control for Stage II, with the gas generator exhaust providing roll control. Guidance commands come from the Centaur system while stability is controlled by the Titan flight control system.

The two five-segment solid strap-on motors use powdered aluminum fuel and ammonium perchlorate oxidizer in a plastic binder. Both burn for approximately 122 seconds. The two solid motors are generally referred to as Stage "O." Each carries a tank for nitrogen tetroxide mounted on the side of the motor for thrust vector control. The nitrogen tetroxide is injected through the nozzle to deflect the motor thrust for flight control.

CENTAUR D-1T

The Centaur vehicle is 9.1 meters (30 feet) long and 3 m (10 ft.) in diameter. The tank structure is made from pressure stabilized stainless steel .3 millimeters (0.014 inches) thick in the cylindrical sections. This is approximately the thickness of a dime. Pressure stabilized means that the strength of the vehicle structure depends on pressure inside the tanks and it has often been called a balloon type structure. When the vehicle is not pressurized it must be kept in a special cradle which keeps it stretched to retain its shape.

A double-walled vacuum-insulated bulkhead separates the liquid oxygen section from the liquid hydrogen tank. The forward equipment module attaches to the tank by a short conical stub adapter. The stub adapter is also used as an attach point for a truss type adapter for payloads weighing more than 1,814 kilograms (4,000 pounds). Spacecraft smaller than that are supported by a payload adapter mounted on the forward end of the equipment module.

The entire cylindrical portion of the D-1T vehicle is covered with a new permanent radiation shield consisting of three separate layers of an aluminized mylar, dacron net sandwich. The forward tank bulkhead and tank access doors are insulated with a number of layers of aluminized mylar. The aft bulkhead is covered with a dacron-reinforced aluminized mylar membrane and protected further with a rigid radiation shield supported on brackets. The radiation shield is made of laminated nylon fabric with aluminized mylar on the inside and white polyvinyl fluoride on its outer surface, and is necessary to limit the loss of propellants resulting from solar heating during long duration missions.

This permanent insulation system will allow the Centaur stage to coast up to five and a quarter hours in space and restart its engines. This added capability, over former Centaur vehicles, for coast is necessary for synchronous orbit missions.

Additional hydrogen peroxide for attitude control and propellant settling as well as additional helium for tank pressurization have also been added to the D-1T vehicle to allow for extended missions.

Primary propulsion for the Centaur is its two RL-10A-3-3 engines which provide 66,720 newtons (15,000 lbs.) thrust each.

During coast, separation and retromaneuvers, attitude control and propellant settling are provided by 12 small hydrogen peroxide thrusters rated at 26.7 N (6 lbs.) thrust.

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The Centaur D-1T astrionics system consists primarily of a Teledyne digital computer unit, and a Honeywell inertial reference unit. The 27.2 kg (60-lb.) digital computer has a 16,000 word random access memory. The inertial reference unit contains a four-gimbal, all-attitude stable platform. Three gyros stabilize this platform on which are mounted three pulse-rebalanced accelerometers.

The Centaur astrionics system handles navigation, guidance tasks, propellant, and tank pressure management, telemetry formats and transmission, and initiates vehicle events. The system also performs a major role in checking itself and other vehicle systems prior to launch. One of its major advantages is the increased flexibility the new astrionics system offers over the original Centaur system. In the past, hardware frequently had to be modified for each mission. Now most operational needs can be met by changing the computer software.

The Titan III vehicle previously used a radio guidance system. Modifications to mate it with Centaur were designed to retain as much Titan autopilot and programming sequence capability as possible. To keep modifications to the Titan and connections between stages as simple as possible, the Centaur guidance system feeds signals to the Titan flight computer and lets it send the proper commands to Titan systems.

DELTA STAGE

The Delta Stage (alternately referred to as Fourth Stage or TE-M-364-4 Stage) major assemblies consist of a spin table, TE-M-364-4 solid propellant rocket motor, batteries, telemetry and tracking systems, and a payload attach fitting. The spin table's lower (non-rotating) conical adapter is attached to a cylindrical adapter on the Centaur. The spin table assembly includes a four-segment petal adapter mounted on a bearing attached to the non-rotating conical adapter. During spinup, the eight spin rockets which are mounted on the spin table are ignited, two redundant motor separation clamp explosive bolt assemblies are initiated, and centrifugal force swings the adapter segments back on their hinges to free the Delta Stage, the payload attach fitting and the Helios spacecraft.

The TE-M-364-4 rocket motor provides an average thrust of 66,454 N (14,900 lbs.)over its action time of about 44 seconds.

The base of the attach fitting is attached to the forward support ring of the TE-M-364-4 motor. The Helios spacecraft is fastened to the attach fitting by means of a V band clamp. Four separation springs are utilized, each exerting a force of approximately 130 pounds on the spacecraft in the mated configuration.

CENTAUR STANDARD SHROUD

The Centaur Standard Shroud provides a large payload space on the Titan Centaur. In most configurations a payload nearly 8.5 m (28 ft.) long can be accommodated. Inside clearance of the shroud is 3.8 m (12 and a half ft.). A manufacturing joint is provided which allows for future shroud growth if a need for longer payload accommodations arises.

The nose cap is made from corrosion-resistant steel attached to two conical sections of magnesium. The cylindrical sections are made of corrugated aluminum. A seal and insulation allows a clean and thermally controlled environment in the payload area.

The two halves of the Centaur Standard Shroud join along a longitudinal split line. Approximately 60 seconds after Titan Stage II ignition, the longitudinal and horizontal split lines are severed by a noncontaminating pyrotechnic system. Four compressed springs force the two halves to separate. The cone shaped bottom section of the shroud is bolted to the interstage adapter and is jettisoned later with the Titan stage.

That portion of the Centaur Standard Shroud which surrounds the Centaur vehicle contains 8.3 centimeter (3.3 inch) fibreglass insulation. This section reduces heat transfer to the Centaur liquid hydrogen and oxygen propellant on the launch pad and during ascent through the atmosphere.

THE COUNTDOWN

TC-2 launch preparations were made by a government/industry team. The countdown will be conducted by a team of about 150 with representatives from NASA's Kennedy Space Center and Lewis Research Center, Goddard Space Flight Center, General Dynamics/Convair, Pratt & Whitney, Martin Marietta Corp., the United Technology Center, Lockheed Missiles & Space Co., McDonnell Douglas, Aerojet Propulsion Co., RCA and Pan American World Airways. Representatives of the Air Force Space and Missile Systems Office and 6555th Aerospace Test Group are acting in a consultant role to NASA for the Titan booster.

Launch readiness activities will begin with the readiness count which will be picked up eight days prior to launch.

Launch readiness activities will include:

F-8 days	Start readiness count, install CSS separation pyrotechnics.
F-7 days	Install Solid Motor and Titan Core ordnance and Centaur flight ordnance.
F-6 days	Solid rocket motor and Titan integrity inspections. Titan and Centaur system preparations started.
F-5 days	Fuel is loaded for Titan first and second stages.
F-4 days	Oxidizer is loaded for Titan first and second stages and solid rocket motor tanks. Centaur batteries are installed.
F-3 days	Install and connect core vehicle ordnance. Centaur peroxide tanks all loaded. Centaur ordnance is connected.
F-2 days	Final spacecraft checks are performed. Range safety system checks are conducted, Titan Centaur destructors are installed.
F-1 day	Titan propellant tanks are pressurized.

LAUNCH WINDOWS

Three factors must be considered in establishing the launch windows for the Helios mission... relationship between the Earth and Sun, tracking constraints and launch azimuth constraints dictated by safety considerations.

Helios could be launched virtually any day of the year. The window extends approximately an hour based on safety and Earth-Sun relationship but may be limited to 45 minutes due to tracking considerations.

The times for the earliest possible launch dates are listed below.

Launch Date	Time (EST)
December 8	2:16 a.m.
December 9	2:14 a.m.
December 10	2:11 a.m.
December 11	2:08 a.m.
December 12	2:05 a.m.
December 13	2:03 a.m.
December 14	2:00 a.m.
December 15	1:57 a.m.

TITAN CENTAUR FLIGHT SEQUENCE

TITAN PHASE

Liftoff occurs approximately two tenths of a second after ignition of the solid rocket motors. At 6.5 seconds into the flight, Titan begins a programmed roll maneuver commanded by Centaur guidance. The roll maneuver and all attitude control during the solid rocket motor powered portion of the flight is accomplished by the Titan thrust vector system injecting liquid nitrogen tetroxide into the solid motor nozzles deflecting the rocket exhaust gases.

Stage I ignition of the Titan occurs when acceleration from the large solid motors reduces to 1.5 g. Approximately 12 seconds later, the solids are jettisoned. Titan Stage I continues thrusting until propellant depletion at approximately T plus 260 seconds.

Titan Stage II ignition occurs at Stage I propellant depletion, and separation takes place approximately one second later. During Stage I and Stage II phases of the flight, the vehicle attitude in pitch and yaw is controlled by the Titan flight control system with guidance steering corrections supplied by the Centaur guidance system.

The Centaur standard shroud is jettisoned by command from the Centaur guidance system approximately 60 seconds after Stage II ignition.

Titan Stage II boosts the vehicle until loss of acceleration due to propellant depletion, approximately 467 seconds after liftoff. The Centaur guidance system commands separation when Stage II acceleration decays to about .012 g. The Centaur interstage adapter is severed by a shaped charge and retro-rockets on the Titan Stage II slow the spent stage.

CENTAUR PHASE

Centaur first main engine start occurs approximately 10 and a half seconds after Titan Centaur separation. Centaur main engine shutdown is commanded by the guidance system when the proper parking orbit is achieved.

Continuous propellant settling will be maintained during the parking orbit coast phase. During most of the coast phase the vehicle is aligned along the inertial velocity vector. Prior to second burn the vehicle is realigned to pitch attitude of approximately four degrees.

The second Centaur burn, of approximately 273 seconds, is terminated by the Centaur guidance system.

DELTA PHASE

The fourth stage consists of a Delta stage using the TE-M-364-4 solid rocket motor and the Helios spacecraft. Upon command of the Centaur digital computer unit 70 seconds after Centaur main engine shutdown (MECO-2) the Delta stage is spun up to approximately 100 rpm. Two seconds later the fourth stage is separated from the Centaur and the Centaur is backed away from the fourth stage. All subsequent fourth stage events are initiated by the Delta stage timer and pyrotechnic ignition delay train which is started by the Centaur two seconds prior to separation. Ignition of the fourth stage motor occurs 42 seconds after separation and burns for approximately 44 seconds. Separation of the Helios spacecraft from the spent fourth stage motor takes place about 72 seconds after completion of its burn.

CENTAUR POST HELIOS EXPERIMENTS

Approximately 5,000 pounds of propellant will remain in the Centaur vehicle at the time of fourth stage separation. Following separation a helium blowdown will be used to back the Centaur away from the fourth stage. Centaur will then begin a one hour coast period using an unsettled or true zero-gravity propellant management mode. At the end of the coast period a propellant settling sequence will be conducted and the main engines ignited for 11 seconds. This coast and re-start sequence will provide data needed for the Mariner/Jupiter/Saturn mission scheduled for 1977.

Following the 11 second third burn, Centaur will be allowed to coast in zero-gravity mode for approximately three hours. During this coast period hydrogen peroxide thrusters will be used to roll the vehicle 180 degrees every eight minutes for thermal control. This and subsequent events will provide data needed for synchronous orbit missions.

At the end of the three-hour coast a boost pump operation and restart sequence experiment is programmed to occur. Ignition is not an important of this experiment, but if it occurs the Centaur main engines will be allowed to burn until the propellant load reaches 800 pounds. This would require a burn of approximately 45 seconds.

A final experiment will be conducted to turn on the boost pumps in the low gravity environment and flow Centaur propellants to chill propellant feed lines. Engine inlet valves will be opened for tank venting and axial hydrogen peroxide thrusters will be operated to propellant depletion.

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TYPICAL FLIGHT EVENTS FOR HELIOS

Flight Events	Sec.	Min.& Sec.	Kilometers	Miles	Km/hr	mph	Km	Miles
Solid Motor Ignition	0	0	0	0	0	0	0	0
Stage I Ignition	111.4	1:51.4	43.1	26.9	4,917	3,055	39.7	24.7
Solid Motor Jettison	122.7	2:02.7	57.7	35.9	5,304	3,295	46.5	28.9
Stage I Cutoff	260.2	4:20.2	-	-	-	-	-	-
Stage II Ignition	260.9	4:20.9	394.7	245.3	14,632	9,092	111.7	69.4
Centaur Shroud Jettison	321	5:21	645.4	401.2	16,292	10,123	138.6	86.1
Stage II Cutoff	467.5	7:47.5	1,421.6	883.4	23,749	14,756	166.2	103.3
Stage II Jettison	473.5	7:53.5	1,460.5	907.5	23,786	14,779	166.8	103.7
Centaur MES-I (Main engine start)	483.7	8:03.7	1,525.9	948.2	23,783	14,777	167.8	104.2
Centaur MECO I (Main engine cutoff)	581.6	8:41.6	2,191.5	1,361.7	26,585	16,519	169.9	105.6
Centaur MES II	1,414.7	23:34.7	8,189.4	5,088.7	26,636	16,550	163.6	101.7
Centaur MECO II	1,687.7	28:07.7	10,559.5	6,558.3	39,224	24,369	233.6	145.1
Centaur/4th Stage Separation	1,759.7	29:39.7	11,297.2	7,020.2	38,942	24,197	328.3	204
4th Stage Ignition	1,801	30:01	11,719.5	7,282.2	38,712	24,055	406.9	252.8
4th Stage Cutoff	1,845	30:45	12,198.8	7,580	49,768	30,924	516.6	321
Helios Separation	1,917.8	31:57.8	13,064.7	8,118	49,180	30,562	793.5	493

LAUNCH VEHICLE CHARACTERISTICS

Liftoff weight, including space	638,726 kilograms 1,408,121 pounds
Liftoff height	48.8 meters 160 feet
Launch complex	41
Launch azimuth	98.7 degrees (at window opening)

	Titan Booster	Centaur Stage
Weight	617,498 kg 1,361,327 lbs.	20,856 kg 45,979 lbs. (including shroud)
Height	29.8 m (98 ft.)	9.6 m (31.5 ft.) (including truss payload adapter but without shroud and interstage adapter
Propellants	Powdered aluminum and ammonium perchlorate in solid motors; Aerozene 50 and nitrogen tetroxide in Stage I and II.	Liquid hydrogen and liquid oxygen
Propulsion	Two solid motors provide 5.3 million newtons (1.2 million lbs.) thrust each. LR87AJ-11, Stage I engine, 2.3 million N (520,000 lbs.) thrust. LR91AJ-11, Stage II engine, 445,000 N (100,000 lbs.) thrust.	Two 66,720-newton (15,000 lbs.) thrust RL-10 engines. Twelve small hydrogen peroxide thrusters.
Velocity	4,917 km per hour (3,055 mph) at Stage I ignition, 14,632 km per hour (9,092 mph) at Stage II ignition, 23,786 km/hr (14,779 mph) at Stage II Separation.	26,585 km/hr (16,519 mph) at MECO I, 39,224 km/hr (24,372 mph) at MECO II, 49,180 km/hr (30,558 mph) at spacecraft separation.
Guidance	Centaur inertial guidance	Inertial guidance

LAUNCH FACILITIES

Helios-A will be launched aboard Titan Centaur from Complex 41 of the Titan III Complex, Air Force Eastern Test Range. Launch will be under the direction of the NASA/John F. Kennedy Space Center's Unmanned Launch Operations Directorate.

The Titan III Complex -- built on manmade islands in the Banana River -- consists of: solid rocket motor servicing and storage areas; a Vertical Integration Building (VIB); a Solid Motor Assembly Building (SMAB); Launch Complexes 40 and 41; and a double-track locomotove system which transports the mated Titan core and Centaur vehicle from the VIB through the SMAB to Launch Complex 41. The rail system covers a total distance of about 20 miles to link the various facilities of the overall complex.

HARDWARE ASSEMBLY

The Titan, Centaur and Centaur portion of the shroud are erected and mated in the VIB on a mobile transporter/umbilical mast structure. Attached to the transporter are three vans housing launch control and monitoring equipment which remain connected to the transporter and vehicle throughout the receipt-to-launch sequence. Upon completion of integrated tests in the VIB, the assembled Titan and Centaur are moved on the transporter to the SMAB. After the solid rocket motors and liquid-fueled stages are structurally mated, the vehicle is moved to the launch complex. A mobile service structure provides access to all mated vehicle stages. An environmental enclosure or "white room" provides protection for the Centaur and the spacecraft. The spacecraft prelaunch operations include checkout, fueling and encapsulation in the payload section of the shroud and mating of the encapsulated spacecraft with Centaur at the launch complex. Spacecraft are assembled and encapsulated at the Spacecraft Assembly and Encapsulation Facility (SAEF) at KSC.

The VIB is a 23-story structure enclosing nine million cubic feet of space. The VIB -- located 20,000 feet from Complex 41 -- has two major functions: launch control and core vehicle assembly and systems checkout. The VIB has four individual bays or cells in which four Titan rockets can be assembled and all systems checked out before the rocket is moved on to the SMAB for mating of the solid rocket motors. The VIB launch control area -- consisting of three rooms -- is the nerve center of the Titan III Complex.

COMPLEX MODIFICATIONS

The complex was modified to support assembly, checkout and launch of the newly configured Titan Centaur, scheduled to boost two Helios probes to the vicinity of the Sun and place two Viking soft-landing spacecraft on trajectories to Mars. Complex 41 is under operational assignment to KSC and necessary modifications were funded by NASA.

The new NASA rocket substitutes the high-energy, hydrogen-fueled Centaur upper stage for the transtage.

Most of the launch complex modifications were required to service the hydrogen-fueled Centaur. Modifications included the laying of concrete foundations for cryogenic handling and storage areas and modifications to work platforms in Cell 1 of the VIB. Also included was the reconfiguring of the "white room" of the Mobile Service Tower to accommodate the Viking spacecraft and a larger payload shroud. The new shroud covers both Centaur and payload.

The first NASA mission launched from Complex 41 was the Titan Centaur-1 test flight launch of Feb. 11, 1974.

TC-2 HISTORY

The Titan first and second stages were received by KSC on June 17 and the Centaur arrived on July 9. The Titan's two stages were erected on their transporter on July 1 and the Centaur upper stage was mated with them on July 11. The Titan Centaur rocket was powered up for the first time on August 29 and a series of electrical and combined systems were conducted while the vehicle remained in the VIB. The Titan Centaur was then moved into the SMAB where the twin solid boosters were mated with the core vehicle on Sept. 5-6. The combined launch vehicle was moved the 2.8 miles from the SMAB to Complex 41 on Sept. 13.

A prototype Helios spacecraft was received by KSC on July 16. Following checkout in Hangar AO at Cape Canaveral Air Force Station it was erected atop the Titan Centaur rocket at Complex 41 for the Terminal Countdown Demonstration, a flight readiness test of the integrated space vehicle. This was successfully completed on Oct. 22.

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The prototype spacecraft -- a "twin" of the flight article -- was demated and returned to Hangar AO on Oct. 24. Helios-A was received by KSC on Sept. 28. It underwent checkout, experiments integration and buildup in Hangar AO. This process was completed during the week of Nov. 4. On Nov. 10, it was moved to the SAEF at KSC. It was mated with its Delta third stage (TE-364) on Nov. 18 and encapsulated in the payload shroud on Nov. 20. It was moved to Complex 41 for mating with the launch vehicle on Nov. 24.

Launch Readiness Verification and Launch Composite Electrical tests were later successfully conducted to clear Titan Centaur-2 for launch.

HELIOS PROGRAM/PROJECT MANAGEMENT

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Ants Kutzer	Project Manager, Gesellschaft fur Weltraumforschung (GFW)
Friedrich Unz	Deputy Project Manager, GFW
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Dr. Albert Opp	NASA Program Scientist
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Roger Mattson	Manager, Titan III

Office of Tracking and Data Acquisition

Gerald M. Truszynski	Associate Administrator

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Joseph Purcell	Director, Engineering Directorate
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Miles Ross	Acting Center Director
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CONTRACTORS

Spacecraft

HELIOS	Messerschmitt-Bolkow-Blohm GmbH, Munich, Prime Contractor

Launch Vehicle

Titan	Martin Marietta, Denver, Prime Contractor for Titan
Centaur	General Dynamics/Convair
TE-364-4	McDonnell Douglas

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